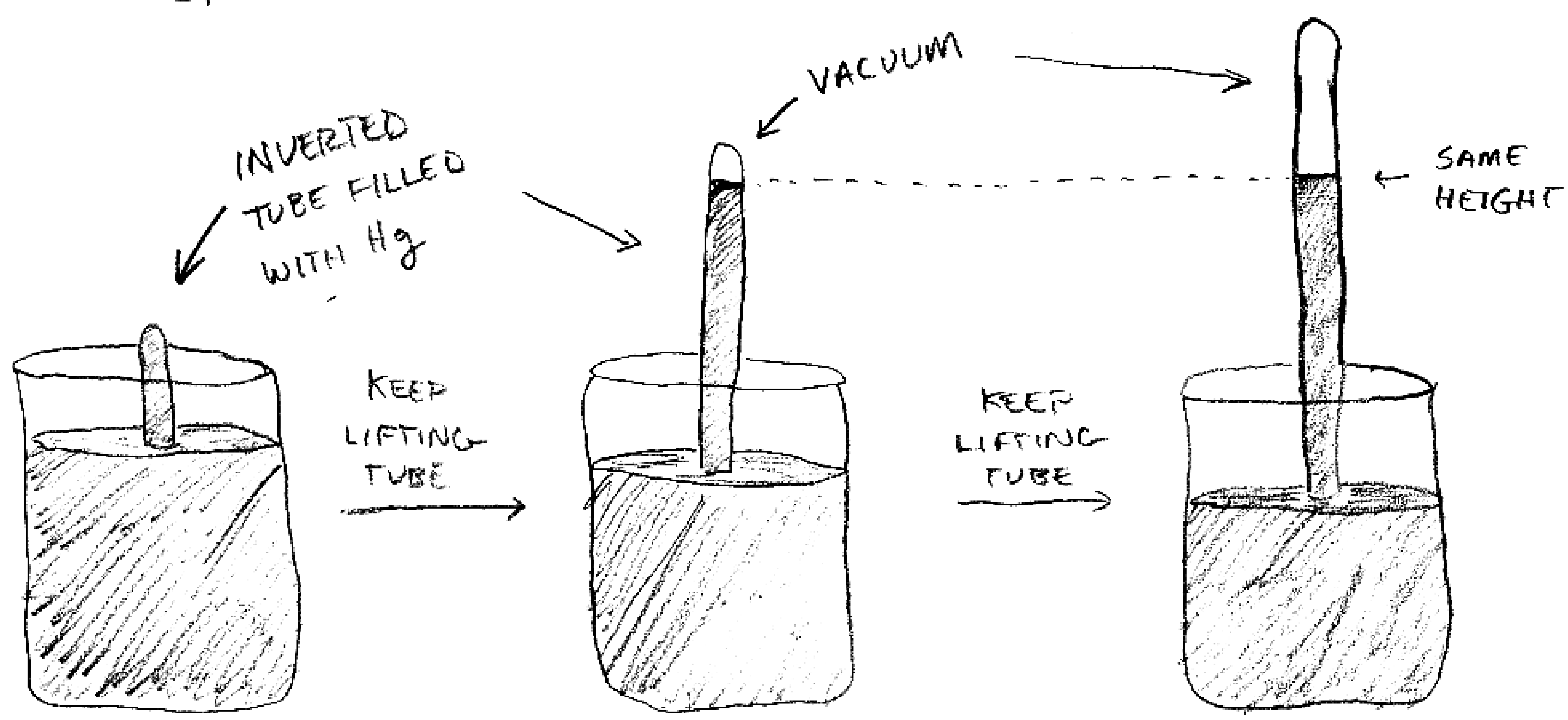
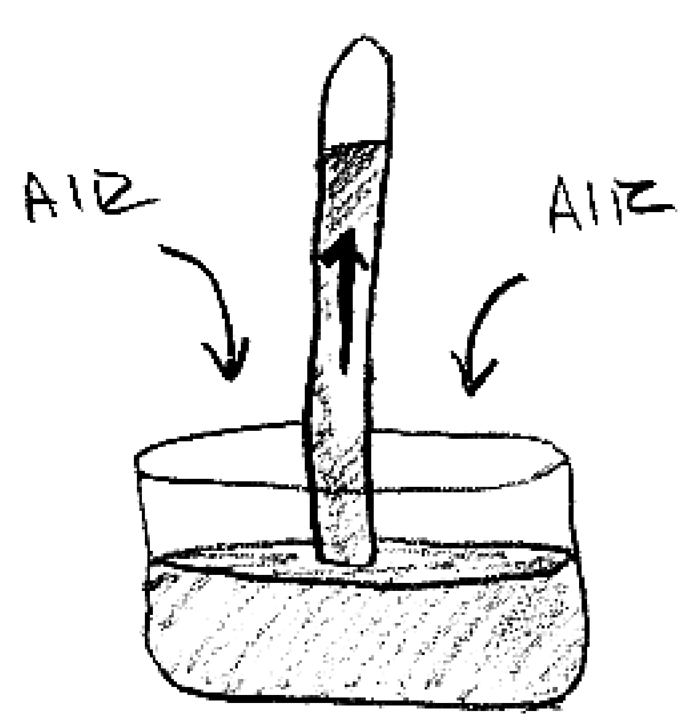
MEASURING PRESSURE:

WE CAN MEASURE ATMOSPHERIC PRESSURE USING A SIMPLE DEVICE KNOWN AS A MERCURY BAROMETER OR A TORRICELLI BARROMETER.



THE HEIGHT OF THIS COLUMN OF MERCURY IS DETERMINED BY THE PRESSURE OF AIR PUSHING THE LIQUID UP THE TUBE.



WHY USE MERCURY?

- LIQUID
- VERY LOW VAPOR PRESSURE
- VERY DENSE (12.595 g/cm³)

THE COLUMN OF MERCURY HAS A DOWNWARD PRESSURE THAT OPPOSES THE PRESSURE OF AIR. WHEN THE TWO ARE EQUAL, THE HEIGHT IS MAINTAINED.

$$P_{Hg\ column} = P_{atm}$$

$$\downarrow$$

$$\text{PRESSURE} = \frac{\text{FORCE}}{\text{AREA}} = \frac{\text{WEIGHT}}{\text{AREA}}$$

$$\text{WEIGHT} = \underset{\substack{\uparrow \\ \text{ACCELERATION} \\ \text{DUE TO GRAVITY} \\ (9.80665\ m/s^2)}}{g} \times \underset{\text{MASS}}{m}$$

SO:

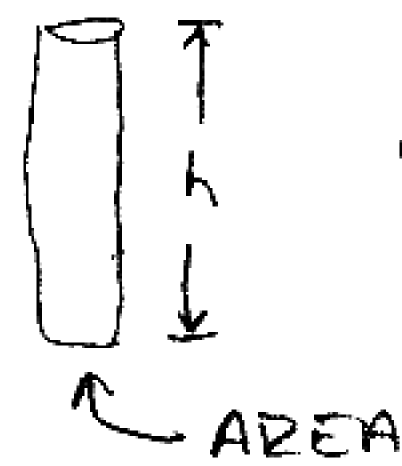
$$P = \frac{W}{A} = \frac{g \times m}{A}$$

MASS = DENSITY × VOLUME

$$\downarrow$$

$$P = \frac{g \times d \times V}{A}$$

VOLUME OF COLUMN



$$V = h \times A$$

$$\downarrow$$

$$P = \frac{g \times d \times h \times A}{A}$$

$$\downarrow$$

$$\boxed{P = g \times d \times h}$$

NOTICE: THE AREA OF THE COLUMN (THE DIAMETER OF TUBE) DOESN'T MATTER

IF THE PRESSURE OF AIR IS 1.010 atm, HOW HIGH WILL THE COLUMN OF MERCURY BE IN MM?

$$g = 9.86655\ m/s^2$$

$$P_{atm} = P_{Hg\ \text{COLUMN}} = g \times d \times h$$

$$\frac{13.595\ g}{cm^3} \times \frac{Kg}{10^3\ g} \times \frac{10^6\ cm^3}{m^3} = 1.3595 \times 10^4\ Kg/m^3$$

$$1.010\ atm \times \frac{101325\ Pa}{atm} \times \frac{Kg\ m^{-1}\ s^{-2}}{Pa} = 1.023 \times 10^5\ Kg/m \cdot s^2$$

SI BASE UNITS

$$P_{atm} = g \times d \times h$$

$$h = \frac{P_{atm}}{g \times d} = \frac{(1.023 \times 10^5\ Kg/m \cdot s^2)}{(9.80655\ m/s^2)(1.3595 \times 10^4\ Kg/m^3)}$$

$$h = 0.7673\ m \times \frac{mm}{10^{-3}\ m} = 767.3\ mm$$

WHAT HEIGHT WOULD A COLUMN OF WATER ($d = 0.998\ g/cm^3$) BE AT THE SAME PRESSURE?

$$\frac{0.998\ g}{cm^3} \times \frac{Kg}{10^3\ g} \times \frac{10^6\ cm^3}{m^3} = 998\ Kg/m^3$$

$$h = \frac{P_{atm}}{g \times d} = \frac{(1.023 \times 10^5\ Kg/m \cdot s^2)}{(9.80655\ m/s^2)(998\ Kg/m^3)}$$

$$h = 10.5\ m \times \frac{mm}{10^{-3}\ m} = 1.05 \times 10^4\ m$$

NOTICE: THIS IS NOT A PRACTICAL HEIGHT

IF A COLUMN OF MERCURY IS EXERTING A PRESSURE OF 760.0 mmHg, WHAT HEIGHT WOULD A COLUMN OF DIETHYLENE GLYCOL ($d = 1.118\ g/cm^3$) BE TO EXERT THE SAME PRESSURE?

$$P_{Hg} = P_{DEG} \Rightarrow \underbrace{g \times d_{Hg} \times h_{Hg} = g \times d_{DEG} \times h_{DEG}}_{\text{CANCEL}} \Rightarrow d_{Hg} \times h_{Hg} = d_{DEG} \times h_{DEG}$$

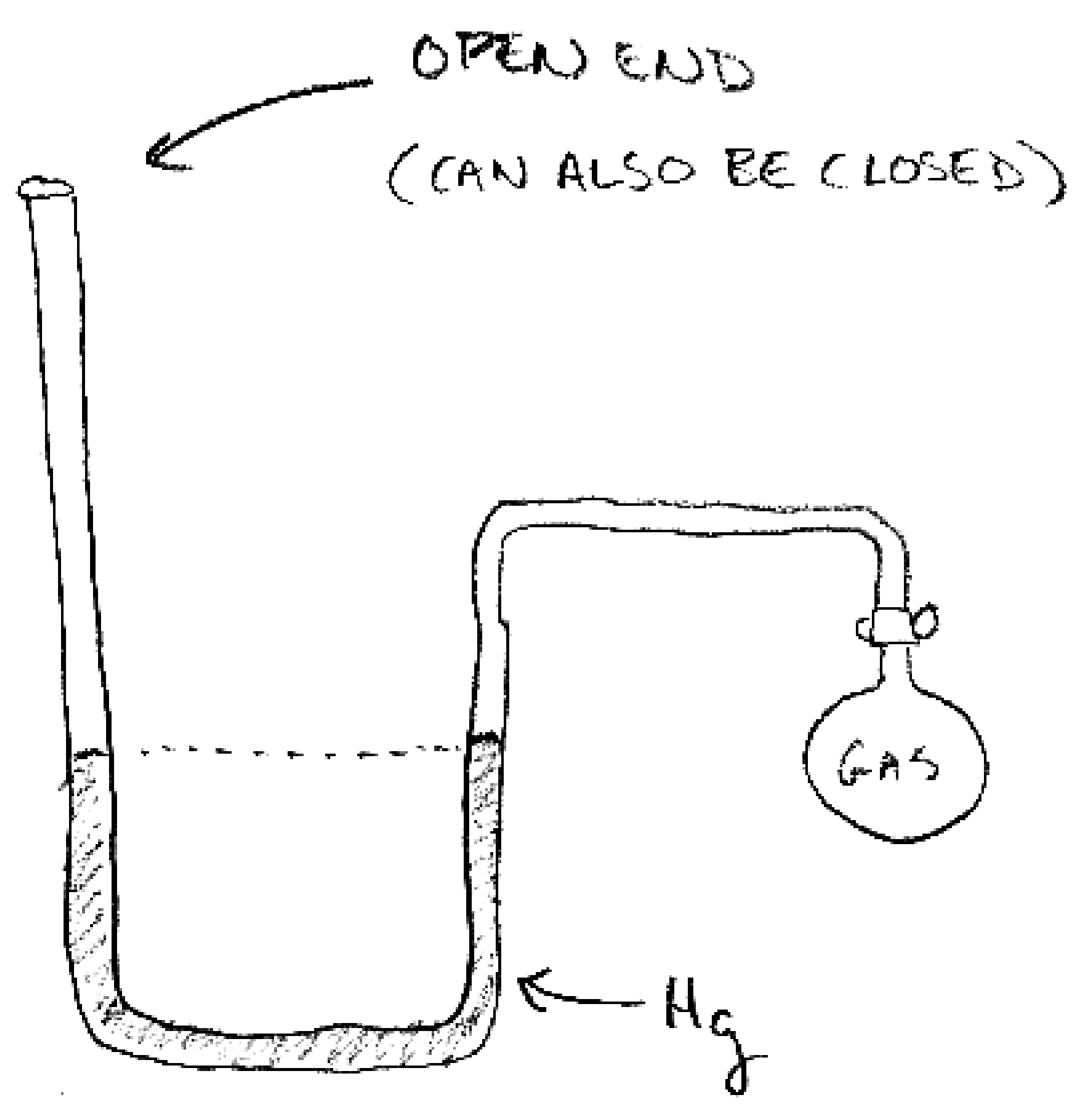
SOLVE FOR h_{DEG}:

$$h_{DEG} = \frac{d_{Hg} \times h_{Hg}}{d_{DEG}} = \frac{(13.595\ g/cm^3)(760.0\ mm)}{(1.118\ g/cm^3)}$$

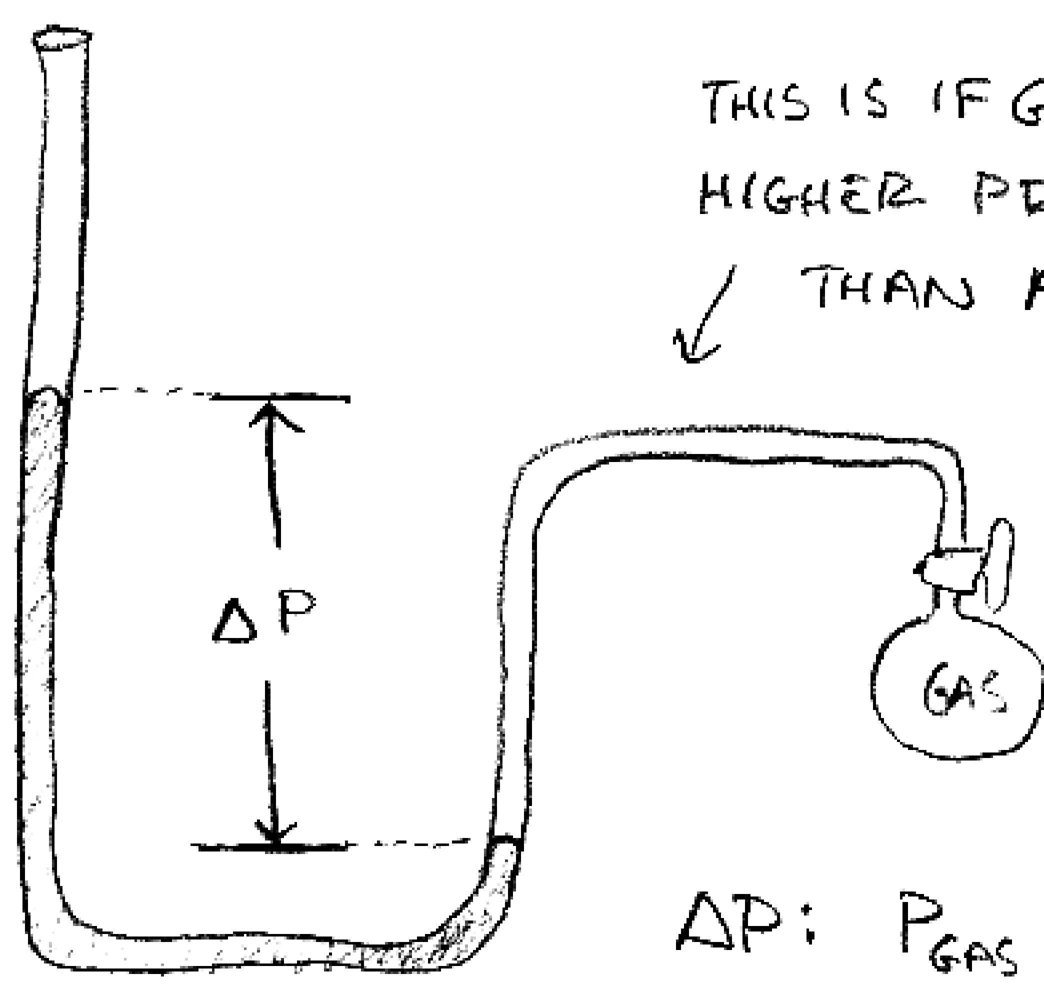
$$h_{DEG} = 9.242 \times 10^3\ mm$$

← COULD HAVE ALSO USED THIS APPROACH FOR WATER

WE CAN MEASURE THE PRESSURE OF A GAS BY COMPARING IT WITH ATMOSPHERIC PRESSURE USING A MANOMETER.



THIS IS IF GAS HAS HIGHER PRESSURE THAN AIR



ΔP: $P_{GAS} > P_{atm}$

$-\Delta P$: $P_{GAS} < P_{atm}$

$P_{GAS} = P_{atm} + \Delta P$

↑

IF NO CHANGE (SAME LEVEL)

$\Delta P = 0$, $P_{GAS} = P_{atm}$

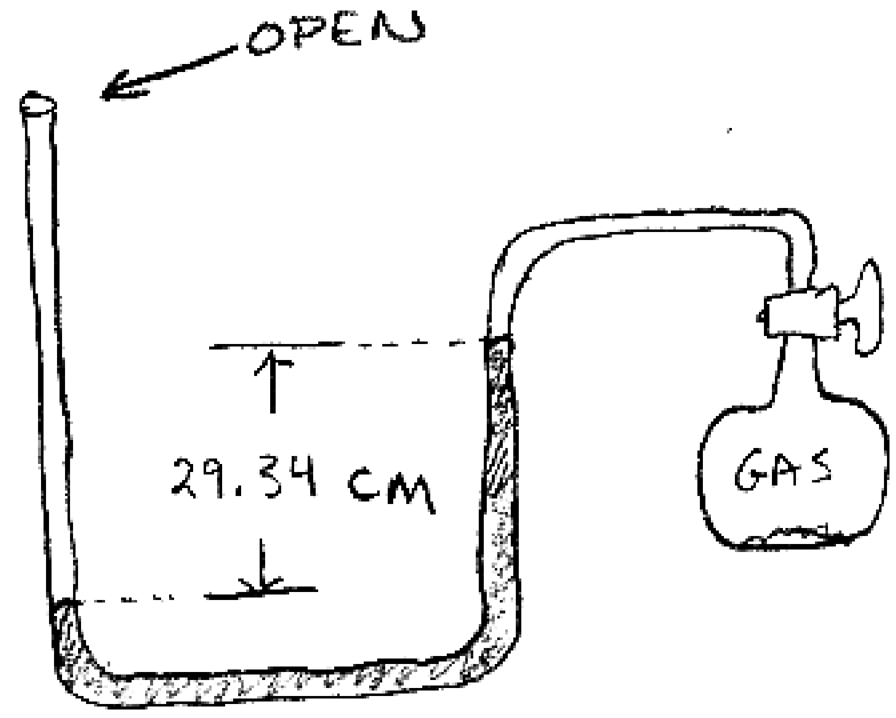
NOTICE: YOU STILL NEED A BAROMETER TO MEASURE P_{atm}

THE LABORATORY BAROMETER READS 767.34 mmHg AFTER CORRECTION. WHAT IS THE GAS PRESSURE IN THE FOLLOWING APPARATUS?

YOU SHOULD BE ABLE TO DO PROBLEMS LIKE THIS

$$P_{GAS} = P_{atm} - \Delta P$$

767.34 mm



$$29.34\,cm \times \frac{10\,mm}{cm} = 293.4\,mm$$

$$P_{GAS} = 767.34\,mm - 293.4\,mm = 473.9\,mmHg$$

IF A GAS HAS A PRESSURE OF 1.039 atm IN THIS APPARATUS, WHAT WILL ΔP BE?

$$1.039\,atm \times \frac{760.0\,mmHg}{atm} = 789.6\,mmHg$$

HIGHER THAN P_{atm}

ΔP IS POSITIVE

$$P_{GAS} = P_{atm} + \Delta P$$

$$\Delta P = P_{GAS} - P_{atm}$$

$$\Delta P = 789.6\,mm - 767.34\,mm$$

$$\Delta P = 22.3\,mm$$